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FUNDAMENTAL DESIGN CONCEPTS FOR THE
LIME STABILIZATION OF LEBANON RAW SLUDGE

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FUNDAMENTAL DESIGN CONCEPTS FOR THE LIME
STABILIZATION OF LEBANON RAW SLUDGE

by

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SUMMARY

On the basis on an economic analysis it is proposed to treat the raw sludge by lime addition to a pH 11.5. This raw sludge is produced by clarification of raw wastewater that has been coagulated with either aluminum sulfate or ferric chloride. The limed sludge would then be drained on sand drying beds, and the cake either given to local farmers or placed in a sanitary landfill. This process would replace the need for biological digestion; it would utilize existing equipment; and it would eliminate all obnoxious odors and pathogenic microorganisms.

Twice the volume of sludge would be produced by the proposed treatment system as is presently produced. The solids content of the new sludge would be about one-half that of the present sludge. These two factors, that of a voluminous and dilute sludge, complicates the handling requirements. Cost savings could be realized by applying the proposed lime stabilization technique to the present primary plus activated sludge mixture.

INTRODUCTION

The Ultimate Disposal and Municipal Waste Treatment Programs cooperated in a plant scale study at Lebanon, Ohio to upgrade the present treatment

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system and remove phosphorus. The sludges generated by coagulation of the raw wastewater with either aluminum sulfate or ferric chloride were treated with lime by Ultimate Disposal Program personnel. This treatment was chosen to eliminate all pathogenic microorganisms, eliminate odors in the sludge, facilitate dewatering of the sludge, simplify its ultimate disposal, and be an economical process for sludge stabilization.

SCOPE

This study includes the following: (1) the findings of a plant scale study of lime stabilization of the Lebanon sludge; (2) a proposed process for sludge disposal at Lebanon, Ohio; (3) a determination of the quantities and characteristics of the sludge to be handled; (4) preliminary specifications of equipment and processes for sludge handling at Lebanon; and (5) economics of the proposed process.

DETAILS OF DESIGN CONCEPT

FINDINGS OF PLANT SCALE STUDY

The sludge obtained from the Lebanon plant had characteristics similar to that of a biological sludge. Its average suspended solids concentration varied from 2 to 3% when either from 150 to 350 mg/l of aluminum sulfate were added to the wastewater or ferric chloride additions ranging from 45 to 90 mg of iron per liter of raw sewage were made. The sludge produced would neither settle nor thicken well and consistently had a bad odor. The procedure routinely followed was to pump 3500 gallons of sludge from the primary clarifiers to a 4000 gallon holding tank, where the solids were kept in suspension and the sludge mixed by air diffusers. A 25 percent lime slurry was then introduced into the tank until the pH reached 11.5. In the instances where

aluminum sulfate had been added to the raw wastewater, about 440 lbs. of lime was required for every ton of dry sludge solids, at a cost of \$3.60. With ferric chloride addition to the raw wastewater, approximately 244 lbs. of lime was required for every ton of dry sludge solids at a cost of \$1.86. The lime was added as Ca(OH)_2 and the cost based on \$16/ton of CaO . The lime was typically contacted with the sludge for 30 minutes, and the sludge was then allowed to flow by gravity to sand drying beds. Limed and unlimed sludge samples were taken for specific resistance, odor, drainability, and pathogen content. These tests are summarized in Table 1. Specific resistance, which is an inverse measure of the sludge's filterability, of the lime treated aluminum sulfate sludge was decreased by a factor of 10 compared to the untreated aluminum sulfate sludge. The specific resistance of the lime treated ferric chloride sludge was decreased by a factor of 3 compared to the untreated ferric chloride sludge. Complete pathogen kill was obtained by lime treatment of both the aluminum sulfate and the ferric chloride sludges. Foul odors emanating from the sludges were completely eliminated as a result of lime treatment. Despite the indications of the specific resistance data, model drying bed studies indicated that lime treatment of these raw sludges had no effect on drainability. In these drying bed studies it was shown that 70% of the total volume originally applied to the beds drained out as filtrate in three days. In three weeks, the sludge cake on the sand beds could be lifted off and disposed of at a landfill site.

PROPOSED LEBANON, OHIO SLUDGE HANDLING SYSTEM

In consultation with the Municipal Waste Treatment Research Program, it was learned that optimum clarification of the raw wastewater and removal of phosphorus were obtained by either the addition of 250 mg/l of aluminum sulfate or 90 mg of iron as ferric chloride per liter of raw wastewater. Therefore the process proposed for sludge handling at Lebanon is to pump the sludge once every 24 hours from the primary clarifiers to the existing anaerobic digester. Removal of the sludge from the clarifiers should be at a sufficiently slow rate to produce the densest sludge. In the digester the sludge will be kept mixed and will have introduced a sufficient quantity of 25 percent lime slurry to elevate the pH to 11.5. After elevation of the pH, a half hour will be allowed for reaction to occur. After this half hour, if sufficient drying bed space is available, the sludge will be removed from the digester by gravity and placed on drying beds. If the drying beds are full, the digester will be utilized as a holding tank.

Once the sludge has had a chance to drain and dry on the beds to a lift-able consistency, it can either be taken away by local farmers for use as a soil conditioner or it can be placed in an existing sanitary landfill. The proposed process is illustrated in Figure 1.

DETERMINATION OF SLUDGE QUANTITIES TO BE HANDLED

From consultation with the Municipal Waste Treatment Research Program, it was learned that the amount of solids removed daily from the primary clarifiers after treatment of the raw wastewater with aluminum sulfate at a level of 250 mg/l was 1545 lbs. Since the minimum sludge solids concentration experienced during our study was 20,000 mg/l, the maximum expected volume of sludge to be produced is 9240 gallons per day. With ferric chloride

addition at a level of 90 mg of iron as ferric chloride per liter of raw sewage treated, the quantity of sludge solids removed was 1451 lbs. per day. For a sludge solids concentration of 20,000 mg/l, this gives a maximum expected sludge volume of 8,700 gallons per day.

PUMPING AND PIPELINE REQUIREMENTS

Conveyance of the sludge from the primary clarifiers to the anaerobic digester can be done with the existing 150 gallon per minute centrifugal non-clog pump. However, since pumps do periodically need cleaning and repair, it would be advisable to purchase another one. Consideration might be given to either a positive displacement-type pump or a Moyno screw-type of pump. Piping throughout the existing system is done with a 6-inch diameter pipe. Since this piping is now approximately 15 years old, it has probably deteriorated considerably and consideration should be given to having it inspected and possibly replaced. This could result in considerable savings in pumping energy requirements.

LIME ADDITION AND MIXING FACILITIES

The existing anaerobic digester at the treatment plant can be utilized for the mixing of lime and sludge, and it can also be utilized as a sludge holding tank. This digester is approximately 50 feet in diameter and 20 feet deep, and has a capacity of 295,000 gallons. Prior to its proposed use it would probably require cleaning. In addition, a mixing device would have to be installed. Mixing could be done with a device similar to Infilco's Vortimixer, having approximately a 20-foot shaft and single rotor. The mixer would need to be adequately sized to handle mixing of a maximum quantity of 300,000 gallons of a two to four percent solid sludge. Following treatment the sludge

could be removed by gravity to sand beds. However the liquid level in the modified digester should always be high enough for the mixer to be effective.

A 25 percent lime slurry had been used in the experimental study. It was calculated from this study that the lime slaker must deliver at least 348 pounds of lime per day to the 9240 gallons of aluminum sulfate sludge. This corresponds to a 25 percent slurry volume of 170 gallons per day. In the case of the ferric chloride sludge 169 pounds of lime would be required per day corresponding to 90 gallons of 25 percent lime slurry. The feeding of the lime slurry to the sludge should be sufficiently low to allow for pH equilibrium to be obtained. The total amount of slurry required will probably be delivered over a two hour period. For this purpose the viscomatic lime slakers manufactured by the Infilco Corporation might be considered. It is further suggested that a pH sensing, monitoring, and recording device properly set to allow sufficient lime contacting and control the on and off of the lime slaker be installed. An automatic probe flushing stage should be part of the device. Suggestions for this kind of pH control device manufacturer are the Honeywell or Leeds and Northrup Companies.

The lime treated sludge can be held in the modified digester while adding additional sludge and lime to it the following day. It can be emptied to the drying beds periodically or when it is full.

SLUDGE DRYING BEDS - NEED FOR ADDITIONAL STORAGE AND BEDS

The amount of sludge to be lime treated each month is a total of 277,000 gallons, which approximates the total capacity of the digester tank (295,000 gallons). Therefore, it would be necessary to lime and place

on drying beds a minimum of 277,000 gallons each month. The existing drying beds have a total capacity of 224,000 gallons when filled to a depth of 24". In all there are 10 drying beds, each of which has an area that is 67 ft. by 24 ft. From the model drying bed study, at this depth the sludge is not expected to dry well enough to be moved after one month, and it will be necessary to build an additional 10 drying beds of the same dimensions to accomplish adequate drying. A sludge holding tank with an approximate capacity of 300,000 gallons will also be needed for the winter months and rainy seasons. We have found that by placing nine inches of sludge on model sand beds, 70% of the original volume will drain through the sand in 3 days, under ideal conditions (21°C, 45% relative humidity, constant lighting). It is suggested that the sludge from the lime treatment tank be placed on the beds in thin layers to allow maximum draining and surface area for evaporation.

SUGGESTED ULTIMATE DISPOSAL MEANS

The consistency of the sludge removed from the drying beds must be sufficiently dry that it can be easily removed and transported. For a landfill operation a sludge with 25% solids or greater would be suitable for ultimate disposal. The landfill must be managed properly and the sludge covered with topsoil. The lime treated sludge can be spread on land without prior drying bed application and provide benefits in reclaiming land or enhancing crop production.

Lime stabilization of sludge produced at the Lebanon treatment plant is a very inexpensive process to incorporate into the existing system. A minimum of instruments and process controls will be necessary for complete sludge stabilization and pathogen removal. Odors at the treatment plant

will be greatly reduced by lime treatment as will maintenance and operation usually performed on biological digesters.

SYSTEM ECONOMY

Factors which have the greatest effect on the cost of the proposed process stem from the nature of chemical sludge as compared to raw sludge from the existing treatment system. The proposed process does not produce a thick sludge, since 3% solids is perhaps as thick as it can be. Comparing this to the 5% concentrated sludge produced by the existing system, we see that a much more dilute sludge has to be handled with the proposed chemical-physical process. Since 3600 gallons of 5% primary sludge plus 2400 gallons of secondary sludge is produced each day, a total of 6000 gallons of sludge is produced by the existing treatment plant. However in the proposed system, 9,240 gallons of 2% primary chemical sludge would be produced. In terms of sludge handling this means doubling the capacity of all sludge tanks and drying beds. This promotes a serious increase in cost for sludge handling.

SLUDGE CHARACTERISTICS

BEFORE AND AFTER LIME ADDITION

Chemical and Chemical Dose	Time Sample Taken	Sludge Suspended Solids (gm/l)	Sludge Dissolved Solids (gm/l)	Sludge Specific Resistance (sec ² /gm x 10 ⁻⁸)	Sludge Pathogen Content (orgs./gal)	Pounds of Lime Required per Ton of Dry Sludge Solids
Aluminum Sulfate 250 mg/l	Before Lime	28.0	1.6	28.0	5,300	440
	After Lime	35.0	-2.3	4.6	Nil	N.A.
Ferric Chloride 45 mg/l added as Fe ⁺⁺⁺	Before Lime	18.0	2.1	21.6	>91,000	244
	After Lime	24.0	2.1	5.5	Nil	N.A.

N.A. means not applicable.

FIGURE 1

Lebanon Sewage Treatment Plant Proposed Modification of Sludge Handling

Ferric chloride
Aluminum sulfate

Raw wastewater

Grit Chamber

Primary Clarifier

Aeration Tank

Final Clarifier

To Stream

Pump

Raw sludge

SAND
Drying Beds

Formers or Land Fill

25% Addition Slurry

ANEROBIC
DIGESTER
CONVERTED TO
MIX + HILL TANK

pH CONTROL

--- = Additional Modification

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